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SCIENCE AND BUSINESS

By John J. Carty
Vice-President of the American Telephone and Telegraph Company

Washington, D. C., June, 1924

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SCIENCE AND BUSINESS

By John J. Carty
Vice-President of the American Telephone and Telegraph Company

I HAVE been asked to address the Chamber on the subject of "Science and Business." More than we yet realize, the future of American business and commerce and industry is dependent upon the progress of science.

The advancement of science is accomplished by scientific research of two kinds. The first is research in pure science, and the second is research in applied science. In the first of these—that relating to the domain of pure science—research is conducted solely for the sake of extending the boundaries of knowledge. In the second, research is conducted for the purpose of applying to practical uses the new knowledge discovered by the pure scientists.

The investigators in pure science are guided by a philosophic purpose directed to the discovery of truth and the advancement of learning. They may be compared to explorers who discover new continents or islands or hitherto unknown territory. They are continually seeking to push forward the frontiers of knowledge.

The work of the pure scientist is conducted without any immediate utilitarian motive, for, as Huxley has well said, "That which stirs their pulses is the love of knowledge and the joy of the discovery of the causes of things, the supreme delight of extending the realm of law and order ever farther towards the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run."

The pure scientists are to be found in our universities and in our very small numbers of institutions for research in pure science. They are the advance guard of civilization. By their discoveries, they furnish to the engineer and the industrial chemist and other

[1] An address to the Chamber of Commerce of the United States, Cleveland, Ohio, May 8, 1924. The speaker was at Washington, D. C. His words were carried by special telephone wires to Cleveland where, by means of a loud-speaking telephone, he was distinctly heard by the entire audience.

workers in applied science the raw material to be elaborated into manifold agencies for the amelioration of the condition of mankind, for the advancement of our business, the improvement of our industries, and the extension of our commerce.

Unless the work of the pure scientist is continued and pushed forward with ever-increasing energy, the achievements of the industrial scientist will, in the course of time, diminish or degenerate. Many problems now confronting us cannot be solved by the industrial scientist alone, but must await further fundamental discoveries and new scientific generalizations. When considered with reference to a single branch of industry, no particular discovery in pure science is likely to appear at first to be of appreciable benefit, but when the total contributions of pure science are reviewed with regard to the industries as a whole, it is found that they have become of incalculable value through adaptations to practical use by the commercial and industrial scientist.

While the discoveries of the pure scientists are of the greatest importance to the higher interests of mankind, the practical benefits flowing from them, though certain, are usually indirect, intangible, or remote. From its very nature, pure science cannot support itself. Nevertheless, it must be conducted regardless of its lack of pecuniary returns. The obligation of the public to support researches in pure science and the advantages which are certain to flow from such support are incalculably great.

Michael Faraday, working in England, and Joseph Henry, working here in America at the same time, made fundamental discoveries in pure science underlying the art of electrical engineering. If we were to subtract from our present knowledge the contributions of these two great men and perhaps those of one or two others, the wonderful structure which our applied scientists, the electrical engineers, have reared upon the foundation of knowledge provided by these investigators would disappear.

But, notwithstanding these practical results which sooner or later are sure to follow from their work, the question for the pure scientists is not so much what use can be made of their discoveries, but rather what message do they bring, what truths do they reveal, what laws do they establish?

An experiment in science is but an hypothetical question put to nature. She will answer truthfully every such question that we ask.

She will make known to us all her secrets if we have but the skill properly to frame our questions and the wit to understand her answers.

It is related that an English statesman before whom Faraday performed his fundamental experiment in electromagnetism asked of him the forbidden question, "What use is it?" Faraday, without revealing the irritation which he must have felt, said, "Some day it may be developed so that you can tax it." Faraday was a good prophet, for upon his fundamental discoveries and those of the American, Joseph Henry, and I might include one or two others, there has been erected by our applied scientists the entire art of electrical engineering. Truly, these discoveries have been developed, for today mankind is in possession of electrical property valued at more than twenty billions of dollars, and evidence is not lacking that others besides Faraday's statesman are busy with the taxing of it.

While the people of the United States and of other countries are under great obligations to support the work of the pure scientist, and while ultimately they will derive immense benefit therefrom, there is not the time at my disposal to develop this idea further.

My principal purpose today is to bring to the attention of the members of the Chamber the very great advantages which will come to them from establishing within their own organizations departments for scientific development and research devoted to the practical purpose of improving their own businesses.

And now, coming to the work of the applied scientists, it can be said with truth that, considering the art of electrical engineering as it exists today, if we were to take away the contributions of the applied scientists, that which would be left would make a sorry showing. The entire art of telephony would disappear, and all of those wonderfully co-ordinated social and business activities depending upon that means of communication would instantly be paralyzed.

In electric lighting and power, and transportation, the contributions of engineers and other applied scientists have been so important and so numerous that it is impossible to picture the chaos which would result if by some black magic their wonderful work should be undone. All of this work, it should be noted, has been accomplished within the last fifty years.

The importance of establishing within their own organizations departments of applied science, or, as they are sometimes called, de-

partments of development and research, has been better appreciated in the chemical and metallurgical and electrical industries than in most others, and the results which these departments have secured for their organizations have abundantly justified the establishment and maintenance of such departments.

I can best illustrate my point by a concrete example drawn from my own experience in the telephone art, which has covered a period of more than forty years.

The Department of Development and Research which is conducted under my direction had very humble beginnings. At first, about the year 1875, it consisted of but one man, and then two, and then others were added. As the years went on, the work of the department proved to be so important and became productive of such good results that the number of workers was steadily increased until at the present time the total personnel of the department includes about 3,000 workers, about half of whom have scientific or engineering training, a large proportion being graduates of our American colleges and universities. The remaining personnel consists of mechanicians, draftsmen, clerical and administrative forces.

In the beginning it was very difficult for us to obtain the necessary financial support even for the very small personnel and the limited laboratory equipment employed. At the present time, the budget of the department amounts to about $8,000,000 a year, and the laboratories alone occupy a large 13-story building providing about ten acres of floor space.

Unlike the laboratories of the pure scientists established for the discovery of fundamental laws and new truths without regard to their immediate utility, these laboratories are devoted to a severely practical purpose. They are organized on a strictly business basis, and the work conducted in them is directed to no other purpose than improving and extending and conducting in a more economical manner the service which we render to the public.

The criterion which we apply to the work conducted in these laboratories is that of practical utility. Unless the work promises practical results it is not undertaken, and unless as a whole the work yields practical results it cannot and should not be continued. The practical question is, "Does this kind of scientific research pay?" If it does, it should be continued. If it does not, it should cease.

A consideration, therefore, of the practical results which have been obtained from this method of working will help us to a better understanding of our subject.

In 1875, the entire telephone plant of the world could have been carried in the arms of a child. It consisted of two crude telephones and about 100 feet of wire, over which Alexander Graham Bell spoke to his assistant, Thomas A. Watson. Starting with such feeble instruments, the personnel of these laboratories by incessant experimentation and the expenditure of immense sums of money have created a new art, inventing, developing, and making improvements great and small in telephone, transmitter, line, cable, switchboard and every other piece of apparatus and plant required in the transmission of speech.

As one of the results of the cumulative improvements in the art coming from this unceasing organized effort, Dr. Bell, in the year 1915, was enabled to talk once more to Mr. Watson through the original historic instrument, although they were thousands of miles apart, the one at San Francisco and the other at New York.

By the work of the applied scientists, these two original telephones have increased marvelously in numbers and in efficiency, and the first telephone line of 100 feet in length has been expanded into a network covering the continent, until the telephone system of the United States alone comprehends over 34,000,000 miles of wire and over 15,000,000 telephone stations located throughout the whole country. The plant composing this system is conservatively valued at more than two billions of dollars.

Pressing on to achieve still greater distances, the staff of these laboratories transmitted for the first time the human voice without the use of wires from Washington across the North American continent to San Francisco and even far out into the Pacific Ocean to the Hawaiian Islands, where words spoken at Washington were plainly heard.

By this same apparatus and by these same scientists, intelligible speech was for the first time transmitted across the Atlantic Ocean from Arlington, Va., and heard at Paris. This was done in the year 1915. But still higher achievements now lie immediately before us.

To this work done in applied science, the people of the United States, and indeed of the world, are indebted for the highly developed telephone apparatus and methods now available for use in all countries, but in our own to an extent far greater than in any other land.

But it is not alone by these general results that I ask you to judge of the importance to the members of this Chamber of employing the services of the applied scientist. I will give some concrete examples showing definite pecuniary returns.

From their very nature, not all the advantages resulting to the telephone system from its researches in applied science are capable of definite evaluation. For example, no one can accurately appraise the value to the public of those improvements without which the present extensive telephonic system of the United States could not have been created. Such figures would be speculative and even when moderately stated would be so large as to be unbelievable.

But I have made a survey of the work done during the period from 1900 to 1920, and choosing only ten items concerning which definite data could readily be obtained, the specific savings amount in round figures to $500,000,000. This means that the plant of the telephone system, if it could have been constructed at all, would have cost that amount more than it has cost. If we were to broaden our inquiry so as to include many other items and to cover the period prior to 1900, I feel sure that this figure would be more than doubled.

The savings represented by these figures accrue to the public in a much larger measure than to the company, for without these scientific developments the service which is now rendered to the public could be given, if at all, only at prohibitive cost.

I think I have said enough to show that the establishment of a department of applied science has been of great advantage to the telephone system and of incalculable benefit to the public.

But the benefits flowing from the application of science to the telephone tell but a part of the story. The scientific development of the telephone gave a great stimulus to the whole electrical art, and following the invention of the telephone came the beginnings of the electric light and power industries. Many of the concerns engaged in these industries likewise established departments of development and research, and the results which they have accomplished by taking advantage of the services of applied scientists have been astonishing in their magnitude and importance.

The results which have been achieved by scientific workers in applied chemistry have also been of extraordinary value to the American industries. So great indeed have been the benefits to industry

and business and commerce through the employment of practical scientific methods that the value of applied science to our practical affairs has been abundantly established.

But the number of concerns which have thus far adopted scientific research as an integral part of their organizations is very limited indeed, and these methods and these ideas which have proved of such great importance in some of our industries have not yet been appreciated and adopted generally. In fact, I think it is true to say that only a beginning has been made.

The message, therefore, which I have to deliver to the members of the Chamber today is that science can be of immense help to business, and that it is only with the aid of science that American business can keep pace with the rapid advances which are now being made throughout the world.

How can the members of this Chamber find out for themselves in what way science can help their business? I am sure that those concerns that have already established departments of scientific development and research will be glad to give to members of the Chamber information concerning their methods and organization.

In addition to this, I wish to call attention to the fact that at Washington are the headquarters of the National Academy of Sciences devoted to pure science, and the National Research Council devoted both to pure and applied science. The latter institution is not organized for the purpose of conducting research for any particular business concern, but it is organized so that together with its other functions it may give advice and help to all of those seeking to find out in what way science can aid their business.

I think it is a matter of deep significance that just at this time the new building which houses both the National Academy of Sciences and the National Research Council has been dedicated. Already I have had conversations with officials of the Chamber of Commerce, the National Academy of Sciences, and the National Research Council looking to the establishment of helpful relations among these three great national bodies. I am a member of all three of them. I am sure that some plan will develop whereby through co-operation between science and business the results which have been obtained in a few industries may become widespread, and that the day will come when a department of development and research will be considered as essential to every industry as is the sales department, or accounting department, or any other department of its organization.

At the dedication of the National Academy of Sciences and National Research Council building in Washington a few days ago, the President of the United States gave a notable address, during which he said: "This magnificent building now being dedicated to science predicts a new day in scientific research. A new sun is rising. It is destined to illuminate the scientific world by illuminating this hall." That these prophetic words of the President will come true, all scientists must agree.

I am sure that this new sun, which is rising as surely as the sun will rise tomorrow, will illuminate also the new home of the United States Chamber of Commerce at Washington. I hope that in this new light the Chamber will investigate the boundless possibilities which must come from the employment of science in the service of business.

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Membership and Organization.—The National Research Council is a cooperative organization of scientific men of America, including also a representation of men of affairs interested in engineering and industry and in the "pure" science upon which the applied science used in these activities depends. Its membership is largely composed of accredited representatives of more than seventy national scientific and technical societies. Its essential purpose is the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

The Council was established at the request of the President of the United States, by the National Academy of Sciences, under its Congressional charter to coordinate the research facilities of the country for work on war problems involving scientific knowledge. In 1918, by Executive Order, it was reorganized as a permanent body. Although partly supported during the war period by the government and primarily devoted at that time to its activities, the Council now derives all of its financial support from other than governmental sources and is entirely controlled by its own representatively selected membership and democratically chosen officers. It maintains, however, a close cooperative relation with government scientific bureaus in connection with various activities.

Research Fellowships

The Council maintains, with the financial assistance of the Rockefeller Foundation and General Education Board—to the amount of one and one-third million dollars—three series of post-doctorate research fellowships.

Fellowships in Physics and Chemistry.—Candidates must already have the doctor's degree or equivalent qualifications and must have demonstrated a high order of ability in research. Address applications to Executive Secretary, Physical and Chemical Fellowships Board, National Research Council, Washington, D. C.

Fellowships in Medicine.—Both graduates in medicine and doctors of philosophy in one of the sciences of medicine, or in physics, chemistry, or biology, are eligible for these fellowships. Address applications to Chairman, Medical Fellowships Board, National Research Council, Washington, D. C.

Fellowships in Biology (including Psychology and Anthropology).—Candidates must already have the doctor's degree or equivalent qualifications and must have demonstrated a high order of ability in research. Address applications to Chairman, Biological Fellowships Board, National Research Council, Washington, D. C.